PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 3 :
C09K 3/28

A1

(11) International Publication Number: WO 83/ 04041

(43) International Publication Date:
24 November 1983 (24.11.83)

(21) International Application Number: PCT/NO83/00017

(22) International Filing Date: 4 May 1983 (04.05.83)

(31) Priority Application Numbers:
821503
823151
451,833

(32) Priority Dates:
7 May 1982 (07.05.82)
17 September 1982 (17.09.82)
21 December 1982 (21.12.82)

(33) Priority Countries:
NO
NO
US

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(81) Designated States: AT, AT (European patent), AU, BE (European patent), BR, CH, CH (European patent), DE, DE (European patent), DK, FI, FR (European patent), GB, GB (European patent), JP, KP, LU, LU (European patent), NL, NL (European patent), NO, SE, SE (European patent).

Published
With international search report.

(54) Title: FIRE RESISTANT MATERIAL

(57) Abstract

A fire or flame resistant material comprising an organic or inorganic matrix or a mixture thereof, 50-450 parts by weight of a filler material comprising aluminum hydroxide per 100 parts of said matrix and 100-600 parts by weight of calcium carbonate or calcium-magnesium carbonate per 100 parts of said matrix. The material can also include one or more of a lubricating agent, an elasticizer, a drying agent, a color-aging agent or an antioxidant agent.

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Fire Resistant Material.

The present invention relates to a fire or flame resistant material. More particularly, the invention relates to a high temperature, heat barrier material having selective, thermoprotective properties at elevated temperatures.

Background Of The Invention

Heretofore, various materials have been proposed as flame or fire retardants. For instance, in the field of fire resistant cable transits, such materials based on neoprenes, silicon foam, inorganic molding materials and mineral wool mats have been utilized. While these known materials exhibit various useful insulation and resistance to fire hazard properties, none of them, simultaneously, exhibit (1) good thermal conductivity under normal use conditions, (2) expansion and plugging properties at elevated temperatures and (3) heat insulating and mechanical protective properties at very high temperatures, such as are encountered during a fire.

The present invention, however, is directed to a fire or flame resistant material which, in addition to exhibiting the above-mentioned characteristics, also has, simultaneously, additional operational and flame or fire resistant properties, and is capable of being produced using relatively inexpensive processes and components.

General Description Of The Invention

When exposed to fire or elevated temperatures the material of the present invention exhibits two basic properties which together provide an active heat barrier thereby protecting

objects requiring protection:

(1) when heated to certain elevated temperatures, an endothermic reaction occurs. One of the by-products of the reaction is water which, in the course of evaporating, cools down the heat exposed surface; and

(2) the material of the present invention, when directly exposed to elevated temperatures, forms an intumescent layer having a firm, foam ceramic-like structure. This intumescent layer shields the remaining non-exposed portion of the thermoprotective material and has good heat insulating properties at temperatures up to 2300°F and higher.

The heat barrier properties of the fire or flame resistant material of the present invention are present only at temperatures above 480°F (250°C). Below this temperature, the material of the present invention is a relatively good heat conductor, thereby dissipating excess heat.

On heating the material of the present invention at the appropriate elevated temperature, the intumescent layer is formed in the material close to the heat source while the portion of the material more remote from the heat source undergoes only the aforementioned endothermic reaction and does not advance to the intumescent stage.

The fire or flame resistant material of the present invention, which is halogen free, gives off a low amount of light gray smoke during a fire. In a test of its heat protection capabilities a 5" x 5" x 3/8" thick specimen when exposed to 2200°F on one side, the temperature on the non-exposed side did not exceed 450°F after 30 minutes of exposure.

The flame or fire resistant material of the present invention, in one embodiment, can be a thermoplastic material that can be extruded, molded and machined. The material of this invention can be rigid or flexible to a certain extent (20% elongation at break). It can also be laminated or reinforced with conventional materials.

The flame or fire resistant material of the present invention is usefully employed, for instance, in the production of walls, floors, ceilings, rooms and cabins where fire protection is required or desired. It can also be employed as a protective covering or coating for mechanical and electrical equipment such as electrical cabinets or housings, fittings, pipes, hoses, cables, panels, cable transits, doors and hatches. Moreover, it is usefully employed in the production of coverings for tanks and pipes housing or carrying explosive contents and found in chemical plants, refineries, vehicles, ships and aircraft.

The flame or fire resistant material of the present invention can also take the form of granules, said granules being manufactured as such or being provided as sub-divided extrudates. These granules, having either a spherical or any appropriate shape and dimensions, may conveniently be used as an insulating material between an inner and an outer surface of a storage unit, such as a storage tank or vessel, especially of larger sizes. Due to the granular form of the flame or fire resistant material, it can easily fill in any space between said surfaces, the shape and dimensions of the granules as well as their property as a bulk material giving the appropriate density of the insulating materials.

In its granular form, the flame or fire resistant material will during normal conditions constitute a "resilient"

insulation allowing for certain differences between the inner and the outer surfaces, as regards variation in structural tolerances and thermal expansions. If a fire should occur, the granules will as a result of the elevated temperature, provide an active heat barrier as explained above. Due to the loose storage of the granules, the granules will during a fire be allowed to expand and fuse together, so as to finally form a firm, intumecent intermediate layer without imparting undue pressure on said surfaces.

Detailed Description Of The Invention

The fire or flame resistant material of the present invention comprises an organic or inorganic matrix, or a mixture thereof; 50-450 parts by weight of a filler material comprising aluminum hydroxide per 100 parts of said matrix; and 100-600 parts by weight of calcium carbonate or calcium-magnesium carbonate per 100 parts of said matrix.

The fire or flame resistant material of the present invention can also contain 30-40 parts by weight of one or more of a lubricating agent, an elasticizer, a drying agent, a color-aging agent or an antioxidant agent, per 100 parts of said matrix.

In one embodiment of the present invention, the fire or flame resistant material can comprise purely inorganic components admixed with water.

In yet another embodiment the matrix can comprise up to 90 weight percent inorganic components, the remainder being organic building agents, loosening agents, thermoplastic materials, tempered plastic materials, elastomers, rubber and the like. The choice of any particular composition can depend on how the ultimate material is to be worked,

for example, molded, injected, extruded, or produced as a coating material to be applied to the object to be protected against fire or heat.

In one preferred embodiment of the present invention the matrix of the fire or flame resistant material is an organic polymer, preferably an ethylene-ethyl acrylate copolymer. In this preferred embodiment the filler material comprises aluminum hydroxide with up to 200 parts by weight thereof capable of being replaced by mica, per 100 parts of said organic polymer matrix. Also in this preferred embodiment, 0-100 parts by weight of the calcium carbonate can be replaced by sodium silicate, while the lubricating agent is paraffin wax present in an amount of about 10 parts by weight per 100 parts of said copolymer matrix.

Moreover, in this preferred embodiment, the elasticizer is ethylene propene rubber present in an amount of about 11 parts by weight per 100 parts of said copolymer matrix and the drying agent is an admixture of calcium oxide and wax present in an amount of about 11 parts by weight per 100 parts of said copolymer matrix.

Further, in this preferred embodiment, the color-aging agent is carbon black present in an amount of about 1 part by weight and the antioxidation agent is poly trimethyl dihydroquinolin, present in an amount of about 1.5 parts by weight, each based on 100 parts of said copolymer matrix.

In still another embodiment of the present invention the fire or flame resistant material can be rigid. In this embodiment the material comprises, per 100 parts of organic matrix, preferably ethylene-ethyl acrylate, 50 to 450 parts by weight of a filler material comprising aluminum hydroxide, 100 to 600 parts by weight of a member selected from the group consisting of calcium carbonate and calcium-magnesium carbonate, 8 to 15 parts by weight of a lubricating agent, 8 to 15 parts by weight of an elasticizer, 10 to 15 parts by weight of a drying agent, 1 to 2 parts by weight of a coloring agent and 0 to 1,5 parts by weight of an antioxidant.

A representative rigid fire or flame resistant material of the present invention is one containing, per 100 parts of ethylene-ethyl acrylate, as the matrix, 220 parts by weight of aluminum hydroxide, 220 parts by weight of calcium carbonate, 10 parts by weight of a lubricant, 11 parts by weight of an elasticizer, 11 parts by weight of a drying agent, 1 part by weight of a coloring agent and 1.5 parts by weight of an antioxidant.

In yet another embodiment of the present invention the fire or flame resistant material can be flexible. In this embodiment the material comprises, per 100 parts of organic matrix, again preferably ethylene-ethyl acrylate, 130 to 170 parts by weight of a filler material comprising aluminum hydroxide, 130 to 170 parts by weight of a member selected from the group consisting of calcium carbonate and calcium-magnesium carbonate, 8 to 15 parts by

weight of a lubricating agent, 25 to 40 parts by weight of an elasticizer, 10 to 15 parts by weight of a drying agent, 1 to 2 parts by weight of a coloring agent and 0 to 1,5 parts by weight of an antioxidant.

A representative flexible fire or flame resistant material in accordance with the present invention is one containing 30 parts by weight of ethylene-ethyl acrylate, as the matrix, 150 parts by weight of aluminum hydroxide, 150 parts by weight of calcium carbonate, 10 parts by weight of a lubricant, 30 parts by weight of an elasticizer, 11 parts by weight of a drying agent, and 1 part by weight of a coloring agent.

When the material of the present invention is used for the production of fire resistant cable transits it will expand due to the presence therein of aluminum hydroxide, under the influence of intense heat, for example, fire or radiated heat, such that the material blocks any permeation of smoke, warm gases and flames along the transits. If a portion of the aluminum hydroxide is replaced with mica, whether natural or hydrated, the degree of expansion can be varied within fairly wide limits, since the addition of mica imparts to the material a dough-like consistency and provides greater expansion of the material at high temperatures.

In addition, the function of the aluminum hydroxide as an expansion agent can be partially replaced and regulated with an organic expansion agent, such as, azodicarbonamide.

At temperatures above the combustion temperature of the organic components, e.g., in a fire situation, the fire

resistant material of the present invention forms a strong intumescent layer having good thermal insulation properties and high thermal stability, i.e., it will withstand heat up to temperatures of 1100°C. The intumescent layer contributes to an effective thermal and mechanical insulation of the articles or objects coated or covered with the material of this invention.

Before burning, the material of this invention is elastic and is very resistant to vibrations and mechanical loads.

In another embodiment of the present invention the matrix can be a concrete mortar.

Yet another alternative is to use as the matrix a component such that the finished product can be employed to coat or paint the object to be protected from fire. Such a component is, for example, a solution or suspension of an alkyd, a polyurethane, a vinyl acetate, an acrylate or the like.

The present invention also relates to a method for producing the fire or flame resistant material defined above, said process comprising mixing the components thereof, dry, at ambient temperature, extruding the resulting admixture at a fusion temperature of about 150-200°C to form extrudates in continuous form and subdividing said extrudates.

The extrudates in continuous form, e.g. string-like form, can be cut into smaller lengths or cubes for temporary storage. These subdivided extrudates can then be extruded at a temperature of about 150-200°C so as to produce covers for the articles or objects to be protected from fire.

Moreover, the flame or fire resistant material of the present invention can easily be extruded to form coatings for cables which are exposed, or more importantly, for cables hidden in walls.

Tests made with the flame or fire resistant material of the present invention show that, for a class A fire test, the material withstood fire for 180 minutes, at which point the test was stopped. By comparison, known PVC materials under essentially the same class A fire test conditions withstood fire for only about 60 minutes at which point the PVC material chemically decomposed and produced dangerous chlorine gas.

In still another preferred embodiment of the present invention, the flame or fire resistant material comprises 90-140 parts by weight of a polymeric matrix material, 14-24 parts by weight of a production lubricating agent, 8-13 parts by weight of calcium oxide, 140-160 parts by weight of calcium carbonate and 140-160 parts by weight of aluminum hydroxide. Moreover this material can also include an effective amount of a color-aging agent, such as carbon black.

The polymeric material comprises preferably, 70-100 parts by weight of ethylene-ethylacrylate copolymer and 20-40 parts by weight of synthetic rubber, e.g. EPDM. The production lubricating agent comprises, preferably, 8-12 parts by weight of polyisobutylene and 6-12 parts by weight of paraffin wax.

The flame or fire resistant material of this embodiment of the invention described immediately above, can be prepared by

mixing together the components thereof, essentially in powder form, at a temperature of approximately 30°C to produce a loose admixture. The resulting dry mixture is extruded through a double screw extruder at a temperature of approximately 130°C. The resulting extrudate is partially cooled and fed through a perforated plate to be chopped into granular form at the exit of the plate. The granules can be stored temporarily at room temperature. Thereafter the granules can be processed into pipe or conduit form through an extruder with gradual heating up to 125°C.

The extruded conduit can be provided with a reinforcing coating, and optionally an outer protective cover, made of, for instance, a plastic material.

A conduit made of the flame or fire resistant material reinforced in this manner is especially useful as a flame-resistant shell for electric cables.

The reinforced conduit described above, forms, when exposed to fire conditions, a strong intumescent layer having good thermal insulation properties and high thermal stability. The intumescent layer contributes to an effective thermal and mechanical insulation of the cables housed therein. The intumescent layer is supported by the reinforcing coating.

As an example of a flame or fire resistant material of the present invention, produced especially in the form of a conduit for protecting electric cables, the following components were mixed together at a temperature of about

30°C, the components being essentially in powder form: 80 parts by weight of ethylene-ethyl acrylate copolymer, 30 parts by weight of a synthetic rubber such as EPDM rubber, 10 parts by weight of polyisobutylene, 10 parts by weight of paraffin wax, 11 parts by weight of calcium oxide, 1 part by weight of carbon black, 150 parts by weight of aluminum hydroxide and 150 parts by weight of calcium carbonate. The resulting dry mixture is then fed through a double screw extruder at a temperature of 130°C, and the extrudate, in partially cooled condition, is then fed through a perforated plate and chopped into granular form at the exit from the plate.

The resulting granules can be stored, if necessary, at normal room temperature for later use, or they can be led directly to an extruder with gradual heating to 125°C for extruding into pipe or conduit form.

The extruded conduit is provided with an outer reinforcement after which, the reinforced conduit is covered with an outer protective coating of, for example, polyvinylchloride, if desired.

The polymeric matrix material, i.e. ethylene-ethyl acrylate copolymer and the synthetic rubber form the elasticizer components of the resulting conduit, and the relative amounts of these two components can be balanced depending on the degree of elasticity desired relative to the amount of filler material which is to be absorbed in the polymeric mixture. Polyisobutylene is added as an aid in

the process of mixing the filler material in the polymeric mixture, and paraffin wax is added as a lubricating agent to give the mixture sufficient pliability during the manufacturing process.

Calcium oxide, which absorbs moisture in the mixture, is added in suitable quantities as a drying agent to reduce the danger of pore effects when the polymeric materials and the various additives are mixed. The calcium oxide also contributes to a more homogeneous mass.

Carbon black is employed as a coloring agent. It also imparts to the mixture a certain degree of protection against oxidation.

The filler components, aluminum hydroxide and calcium carbonate, when the material of the invention is exposed to combustion conditions, produce a porous material which does not burn, and the mutual relationship between the additives gives the correct consistency to the foam which occurs on combustion. This foam later stiffens to a strong intumescent layer having good thermal insulation properties and high thermal stability.

The pipe or conduit shaped protective article of the present invention provides good mechanical protection under normal conditions of use and does not produce halogen gases or appreciable smoke upon combustion. Apart from the organic materials, the protective conduit of the present invention does not burn easily and at high temperatures it forms a thermally stable ceramic-like foam intumescent layer which

has good thermal insulating properties, and which is held in place with the aid of reinforcement means such as a braiding of metal or other conventional material.

Under combustion conditions the chemical reaction produces water which as noted earlier has a cooling effect. The material of the present invention also has a low heat of combustion. The protective conduit of this invention can be made using standard equipment, and is relatively inexpensive due to easily available raw materials.

What Is Claimed Is:

1. A fire or flame resistant material comprising an organic or inorganic matrix or a mixture thereof, 50-450 parts by weight of a filler material comprising aluminum hydroxide per 100 parts of said matrix; and 100-600 parts by weight of a member selected from the group consisting of calcium carbonate and calcium-magnesium carbonate per 100 parts of said matrix.

2. The fire or flame resistant material of claim 1 wherein said matrix is an organic matrix comprising an ethylene ethyl acrylate copolymer.

3. The fire or flame resistant material of claim 1 which also includes 30-40 parts by weight of one or more of a lubricating agent, an elasticizer, a drying agent, a color-aging agent or an antioxidant agent per 100 parts of said copolymer.

4. The fire or flame resistant material of claim 1 wherein said filler material comprises 50-450 parts by weight aluminum hydroxide wherein 0-200 parts by weight thereof are capable of being replaced by mica.

5. The fire or flame resistant material of claim 1 wherein 0-100 parts by weight of said calcium carbonate are replaced by sodium silicate.

6. The fire or flame resistant material of claim 3 wherein said lubricating agent comprises paraffin wax present in an amount of about 10 parts by weight per 100 parts of said copolymer.

7. The fire or flame resistant material of claim 3 wherein said drying agent comprises an admixture of calcium oxide and wax, present in an amount of about 11 parts by weight per 100 parts of said copolymer.

8. The fire or flame resistant material of claim 3 wherein said elasticizer comprises ethylene propene rubber present in an amount of about 11 parts by weight per 100 parts of said copolymer.

9. The fire or flame resistant material of claim 3 wherein said color-aging agent comprises carbon black present in an amount of about 1 part by weight per 100 parts of said copolymer.

10. The fire or flame resistant material of claim 3 wherein said antioxidant agent comprises poly trimethyl dihydroquinoline present in an amount of about 1.5 parts by weight per 100 parts of said copolymer.

11. The fire or flame resistant material of claim 3 wherein said filler material also includes an effective amount of azodicarbonamide as an organic expansion agent.

12. The fire or flame resistant material of claim 1 wherein said matrix is an inorganic matrix comprising concrete mortar.

13. The fire or flame resistant material of claim 1, in the form of a coating or painting composition, wherein said matrix is an organic matrix comprising a solution or suspension of an alkyd, a polyurethane, an vinyl acetate or an acrylate.

14. A rigid fire or flame resistant material comprising per 100 parts of an organic matrix, 50 to 450 parts by weight of a filler material comprising aluminum hydroxide, 100 to 600 parts by weight of a member selected from the group consisting of calcium-carbonate and calcium-magnesium carbonate, 8 to 15 parts by weight of a lubricating agent, 8 to 15 parts by weight of an elasticizer, 10 to 15 parts by weight of a drying agent, 1 to 2 parts by weight of a coloring agent and 0 to 1,5 parts by weight of an antioxidant.

15. The rigid fire or flame resistant material of claim 14, comprising 100 parts of ethylene-ethyl acrylate as the matrix, 220 parts by weight of aluminum hydroxide as a filler, 220 parts by weight of calcium carbonate, 10 parts by weight of a lubricant, 11 parts by weight of an elasticizer, 11 parts by weight of a drying agent, 1 part by weight of a coloring agent and 1.5 parts by weight of an antioxidant.

16. A flexible fire or flame resistant material comprising per 100 parts of an organic matrix, 130 to 170 parts by weight of a filler material comprising aluminum hydroxide, 130 to 170 parts by weight of a member selected from the group consisting of calcium carbonate and calcium-magnesium carbonate, 8 to 15 parts by weight of a lubricating agent, 25 to 40 parts by weight of an elasticizer, 10 to 15 parts by weight of a drying agent, 1 to 2 parts by weight of a coloring agent and 0 to 1,5 parts by weight of an antioxidant.

17. A flexible fire or flame resistant material comprising 30 parts by weight of ethylene-ethyl acrylate as the matrix, 150 parts by weight of aluminum hydroxide as a filler, 150 parts by weight of calcium carbonate, 10 parts by weight of a lubricant, 30 parts by weight of an elasticizer, 11 parts by weight of a drying agent and 1 part by weight of a coloring agent.

18. A method for producing the fire or flame resistant material of claim 1 comprising mixing the components thereof dry at ambient temperature, extruding the resulting admixture at a fusion temperature of about 150-200°C to form extrudates in continuous form and subdividing said continuous extrudates.

19. Sub-divided extrudates made in accordance with the method of claim 18.

20. A method for producing a fire or flame resistant coating for articles to be protected against fire comprising extruding the sub-divided extrudates of claim 19 at a temperature of about 150-200°C into a desired shape.

21. A fire or flame resistant material, comprising 90-140 parts by weight of a polymeric material, 14-24 parts by weight of a lubricating agent, 8-13 parts by weight of calcium oxide, 140-160 parts by weight of calcium carbonate and 140-160 parts by weight aluminium hydroxide.

22. The fire or flame resistant material of claim 21 which also includes an effective amount of a color-aging agent.

23. The fire or flame resistant material of claim 21 wherein said polymeric material consists of 70-100 parts by weight ethylene-ethyl acrylate copolymer and 20-40 parts by weight synthetic rubber and wherein said lubricating agent consists of 8-12 parts by weight polyisobutylene and 6-12 parts by weight paraffin wax.

24. A method for producing the fire or flame resistant material of claim 21 comprising mixing the components thereof, essentially in powder form, to produce a loose admixture, at a temperature of about 30°C, extruding the resulting admixture at a temperature of about 130°C, cooling the extrudate and subdividing the extrudate into granules for storage at ambient temperature.

25. The granules made in accordance with the method of claim 24.

26. A method for producing a fire or flame resistant material in tube form comprising extruding the granules of claim 25 at a temperature up to 125°C.

27. The extruded fire or flame resistant material in tube form made in accordance with the process of claim 26.

28. The extruded fire or flame resistant material in tube form of claim 27 provided with an external steel brading and an outer protective coating.

29. The extruded fire or flame resistant material of claim 28 wherein the outer protective coating is a plastic material.

30. The use of the fire or flame resistant material of claims 1 to 17 or 21 to 23 in the production of coverings for mechanical and/or electrical or any energy converting equipment, such as cabinets or housings, fittings, pipes, houses, cables, panels, cable transits, doors, tratches and building structures.

31. The use of the fire or flame resistant material of claim 1 to 17 or 21 to 23 in the production of coverings for vessels, tanks and pipes housing or carrying explosive contents and found in chemical plants, refineries, vehichles, ships and aircraft.

32. The use of the fire or flame resistant material of claims 1 to 17 or 21 to 23 in the production of granules or bulk material, said granules comprising shapes and dimensions adapted to fill any gaps or spaces prepared for fire insulation.

33. The use of granules or bulk material of claim 32, said granules having a shape and size and a packing density at normal temperature allowing for thermal expansion in said gaps or spaces during a fire.

34. The use of the fire or flame resistant material of claims 1 to 17 or 21 to 23 in the production of fire insulating coverings laminated or reinforced with conventional material.

INTERNATIONAL SEARCH REPORT

International Application No PCT/N083/00017

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC 3

C 09 K 3/28

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 3	C 09 K 3/28, C 09 D 5/18
US Cl	252:8.1; 106:15, 18

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category [6]	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	Patent Abstract of Japan, abstract of JP 50-141 739 31 May 1977	
Y	Patent Abstract of Japan, abstract of JP 51-42 762 21 October 1977	
Y	Patent Abstract of Japan, abstract of JP 51-73 990 6 January 1978	
Y	WO, 80/02086 (PEDLOW J WATSON) 2 October 1980 & EP, 0 025 433	
Y	US, A, 4 095 985 (VAST PRODUCTS INC.) 20 June 1978 & CA, 1 097 455	

.../...

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [9]
1983-07-19	1983 -07- 26

International Searching Authority [1]	Signature of Authorized Officer [20]
Swedish Patent Office	Marie-Louise Ebbinghaus

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ... ... because they relate to subject matter [13] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

Claim 1 comprise two inventions. One where the matrix is of inorganic nature and one where it is organic.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4 ☒ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
Y	DE, A, 2 900 535 (STAHL JOEL S) 8 November 1979 & US, 4 122 203 GB, 2 011 914 JP, 54 107 934 CA, 1 120 171 AU, 520 430	